USGS NSF GRIP Opportunity

USGS Center:	Fort Collins Science Center; Menlo Park Science Center
Project Title:	Bioaccumulation dynamics of uranium in aquatic insects
Project Hypothesis or Objectives:	The USGS designed a 15-year Grand Canyon Science Plan to conduct research to reduce the uncertainties in understanding the potential environmental effects of uranium (U) mining to water and biological resources. The goal of the Grand Canyon Science Plan is to help facilitate decision making by the Secretary of the Interior with regard to future decisions on the 2012, 20-year withdrawal of federal lands near the Grand Canyon Region from future uranium mining. While much of the current research has focused on exposures associated with active and reclaimed mines, less is known about the underlying processes that govern U bioaccumulation and toxicity to biota, especially species native to the Grand Canyon Region. However, recent surveys of U in water and biota by USGS and others demonstrated that: 1) U concentrations in water are relatively low in the mainstem Colorado River but are higher, and in some cases exceed, EPA water quality criteria in tributaries and springs draining rocks with naturally high U concentrations; 2) larval insects accumulate U to concentrations 3-4 orders of magnitude higher than water concentrations; and 3) larval insects appear to shed much of this accumulated U during metamorphosis from aquatic larvae to winged, terrestrial adults. Experimental studies with a proxy species to the native Kanab amber snails show that 1) hardness, pH, and dissolved organic matter attenuates U uptake from water and 2) solid-phase U species, including U-rich particles that aggregate and settle onto the streambed, potentially represent an important source of dietary U to benthic grazers. Here, we propose to conduct a series of laboratory experiments to develop a mechanistic understanding of U accumulation and elimination dynamics for a model insect, the mayfly Neocloeon triangulifer. The purpose of the experiments will be to characterize uptake and elimination rate constants of U after waterborne and dietborne exposure to this laboratory organism. A range of realistic ambient U concentrations derived from recent stream survey data from the Grand Canyon will be used in addition to dietary U

concentrations representative of those reported in biofilms collected in spring outflows in the Grand Canyon Region. The planned experiments will allow us to identify the physiological and cellular mechanisms underpinning those processes governing U accumulation dynamics. Further, these results will compliment and extend similar studies of U bioaccumulation dynamics in a model aquatic mollusk (the snail *Lymnaea stagnalis*) conducted by USGS scientists at Menlo Park. Specifically, these experiments will address the following hypotheses:

1) Aquatic insects shed metals such as U during metamorphosis and thus pose little risk to terrestrial predators that feed on the adult life stage of these insects;
2) U exposure alters insect survivorship during metamorphosis.

Duration:	6 months
Internship Location:	Fort Collins, CO; Menlo Park, CA
Area of Discipline:	Ecology, Ecotoxicology, Geology, Biogeochemistry, Hydrology
Expected Outcome:	Results from this study will inform the Department of Interior's decision making regarding U mining on Federal lands by quantifying the risks of U exposure to aquatic organisms and their terrestrial predators. Specifically, this project will contribute to resolving the fate of U in an aquatic insect species across its life history. In addition to providing crucial information on the physiological processes governing U bioavailability in grazing species, it will be the first to our knowledge to explicitly test how U alters survival of insects through metamorphosis. It fills a critical gap in our knowledge of the effects of U on linked aquatic-terrestrial ecosystems. Existing field data and literature reviews suggest that adult aquatic insects have lower concentrations of U than larval aquatic insects, yet the mechanism behind this loss is unknown. We expect that many insects exposed to U during larval development will die during metamorphosis. Thus, the effects of U on larval aquatic insects may be different than the effect on adult aquatic insects, and likely different than other invertebrate species inhabiting waterbodies in the Grand Canyon Region. Moreover, we expect that surviving adult aquatic insects will contain lower concentrations of U than larval aquatic insects, due to metal excretion during metamorphosis. The intern will benefit by performing cutting-edge research on the effects of freshwater contaminants on aquatic-terrestrial linkages as well as to expand application of unique techniques to better understand the bioavailability and toxicity of U to an aquatic insect species. The assembled research team provides an exceptional

	opportunity to learn about these effects at multiple scales (basin, population, individual, molecular). This research will help to resolve how contaminants move between ecosystems, and the risk of those contaminants to aquatic and terrestrial wildlife.
Special skills/training Required:	The intern will require knowledge of aquatic invertebrate ecology and ecotoxicology, culturing techniques for aquatic insects and diatoms, and basic sample processing techniques for analytical chemistry. The intern will receive additional training in diatom dosing techniques and processing tissues for subcellular partitioning.
Duties/Responsibilities:	The intern will work collaboratively with all mentors to conduct the experiment. The candidate intern will split time between the Menlo Park NRP campus and the Fort Collins Science Center (FORT). The intern will apply techniques for characterizing U bioaccumulation dynamic parameters in the mayfly N. triangulifer as well as assessing the subcellular partitioning of U in insect tissues. The intern will run the exposure and elimination experiments, making use of the facilities and existing mayfly culture at the Aquatic eXperimental Lab (AXL) housed at Fort Collins, CO. Duties include daily checks on the mayfly culture, proper sampling and storage of water quality samples, proper collection and preservation of insect tissues, and preparation of samples for analytical chemistry. The intern will also collect and digitize daily notes and experimental data. Following the experiment, the intern will analyze the data and prepare a manuscript(s) for submission to a peer-reviewed journal. S/he will report directly to Dr. David Walters with weekly updates on the progress of the experiment, and lead monthly conference meetings with the mentorship team. This is a multidisciplinary team of USGS scientists including geologists, geochemists, biogeochemists, hydrologists, ecologists and ecotoxicologists.
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